

## **Opto-Package Specifications (draft 25/10/99)**

### **1 Introduction**

This note gives the specifications for the on-detector opto-packages for the SCT and Pixel detectors. Detailed specifications are given for the VCSELs, the PINs and for the environmental and radiation conditions for the opto-packages.

### **2 VCSELs**

The specifications for the VCSEL bare die are given in Table 1 below

**Table 1 VCSEL die specifications**

Parameter	Minimum	Typical	Maximum	Units	Notes
Wavelength	820	840	860	nm	
Output power	600	1000	3000	$\mu$ w	Measured with large area photo-detector @10 mA input current (pre-irradiation)
Slope efficiency	100			$\mu$ w/mA	As above
Beam angular divergence			12	degrees	ulensed
Threshold current	2	3	6	mA	
Allowed input current			25	mA	
Forward voltage		2	2.5	V	@20 mA
Reverse voltage			2	V	
Rise/fall time (20%-80%)		<1	2	ns	
Device reliability			1400	FIT	15 <sup>0</sup> C worst case operating temperature

The specifications for the VCSELs in packages are given in Table 2 below

**Table 2 Packaged VCSEL specifications**

Parameter	Minimum	Typical	Maximum	Units	Notes
Wavelength	820	840	860	nm	
Output power	300		3000	$\mu\text{W}$	Coupled into 50/125 $\mu\text{m}$ multimode fibre @ 10 mA input current (pre-irradiation)
Slope efficiency	50			$\mu\text{W}/\text{mA}$	Coupled into 50/125 $\mu\text{m}$ multimode fibre
Threshold current	2	3	6	mA	
Allowed input current			25	mA	
Forward voltage		2	2.5	V	@ 20 mA
Reverse voltage			2	V	
Rise/fall time		<1	2	ns	
Output power after irradiation	300			$\mu\text{W}$	Coupled into 50/125 $\mu\text{m}$ multimode fibre @ 10 mA input current
Device Reliability			1400	FIT	15 <sup>0</sup> c worst case operating temperature

### 3 PINs

The specifications for the PINs are given in Table 3 below

**Table 3 PIN specifications**

Parameter	Minimum	Typical	Maximum	Units	Notes
Wavelength	820	840	860	nm	
Input saturation power	3			mW	
Responsivity	0.4	0.5		A/W	Pre-irradiation
Dark current		<1	50	nA	Pre-irradiation @ -5V
Reverse voltage		1	5	V	Voltage required for complete signal collection (pre-irradiation)
Breakdown voltage	30			V	Absolute maximum
Diameter of active area	100			μm	
Capacitance			2	pF	Measured at 1V bias.
Rise/fall time (20%-80%)		<1	2	ns	
Radiation resistance (a)			40	%	Decrease in responsivity post-irradiation, for bias voltage < 10V
Radiation resistance (b)			10	μA	Leakage current at bias voltage sufficient to satisfy responsivity, worst case T=15°C
Device Reliability			350	FIT	15°C worst case operating temperature

### 4 Package and Environment

#### Materials

The package should be made from materials with low Z (minimal radiation length requirement) non-magnetic and be radiation resistant

#### Dimensions

The package should be no larger than 5.5x5.5x1.6 mm<sup>3</sup>

#### Environmental Conditions

Operating temperature during testing: -25°C to 40°C.

Operating temperature in ATLAS: - 25<sup>0</sup>C to 15<sup>0</sup>C

Equivalent radiation environment (allows for +50% uncertainty see <http://www-pnp.physics.ox.ac.uk/~weidberg/fluences.html>)

500 KGy(Si)

1 MeV equivalent neutron fluences:

for Si devices: 10<sup>15</sup> n/cm<sup>2</sup>

for GaAs (or InGaAs or AlGaAs): 6.4 10<sup>15</sup> n/cm<sup>2</sup>

Magnetic field: 2T

### Cross-Talk

When operated with VDC and DORIC4A chips the cross-talk should not cause a BER > 10<sup>-9</sup> with input optical power of 200 μW at the PIN diode of the TTC link and 20 mA drive current for the VDC outputs. Pseudo-random data for TTC link and asynchronous 40 MHz clocks for VDC. This specification ensures that the cross-talk is negligible even for the worst case conditions (minimum optical power into the PIN and maximum drive current out of VDC).

## 5 Device Reliability

The required reliability tests for dice of VCSEL and PIN are given in Table 4 below.

**Table 4 Reliability of bare dice.**

Parameters	Reference	Condition	Sample Size
Die shear	MIL-STD-883 Mothod 2019		
Wire bond strength	MIL-STD-883 Mothod 2011	5 g	
Accelerated Ageing (High Temperature)		85 <sup>0</sup> C, rated power, 5000 hr.(*1)	25(for ref)

The required reliability for optopackages are based on telecommunication standards modified for the ATLAS operating conditions are given in Table 5 below.

**Table 5 Optopackage reliability**

Parameters	Reference	Condition	Sample Size
Vibration		10G 20-2000Hz 4 min/cy, 4 cy/axis	11
Fiber Pull		0.5kg, 3 times, 5sec	11
Accelerated Ageing (High Temperature)		60 <sup>0</sup> C , rated power, 1000 hr.	25(for ref)
High Temperature		60 <sup>0</sup> C, 100 hr	11

Storage			
Low Temperature Storage		-20 <sup>0</sup> C, 100 hr	11
Temperature Cycling	MIL-STD-883 Mothod 1010	-10 <sup>0</sup> C - 60 <sup>0</sup> C, 500 cycles	11
Damp Heat (if using epoxy)	MIL-STD-202 Method 103 or IEC 68-2-3	40 <sup>0</sup> C, 95% RH, 4days	11
Cyclic Moisture Resistance	MIL-STD-883 Method 1004 or IEC 68-2-38	10+5 subcycles	11

## 6 Link Data Rates and BER

The data links will send NRZ data at a speed of 40(80) Mbits/s for the SCT (Pixel) detector. The TTC links will send the 40 MHz bunch crossing (BC) clock and a 40 Mbits/s command data stream from the RODs to the detector modules. BiPhase Mark encoding will be used to encode the command data onto the BC clock. The BER for the data and TTC link should be less than  $10^{-9}$ .

## 7 Notes and Explanations

- The device reliability (FIT = failures in  $10^9$  operating hours) has been calculated to allow for up to 1% failures over the lifetime of ATLAS ( $10^8$  seconds). VCSELs are only on while sending “1”s which will be for ¼ of the LHC time assuming 50% utilisation of the bandwidth and sending equal numbers of 0s and 1s.
- The operating temperature for the opto-packages in the SCT barrel will be in the range  $-25^0\text{C}$  to  $-15^0\text{C}$ . The operating temperature for the forward SCT will be a maximum of  $15^0\text{C}$  (estimate from Tony Smith, Liverpool). It is not yet decided where to place the optics for the Pixel detector. If it is placed on the module the temperature will be in the range  $-25^0\text{C}$  to  $-15^0\text{C}$  but if it is placed on the flex cable then the temperature might be as high as  $\sim 15^0\text{C}$  (assume that it would be similar to forward SCT case).
- The radiation environment has been calculated for the worst case of the Pixel layer 1 assuming 3 years of low luminosity and 7 years of high luminosity ( $10^{34} \text{ cm}^{-2}\text{s}^{-1}$ ). An ATLAS year is defined as  $10^7$  seconds . See <http://www-pnp.physics.ox.ac.uk/~weidberg/fluences.html>
- The maximum leakage current in the PIN diode is specified to allow for the effects of 1/f noise (estimate from Dave White who designed DORIC4).